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The Effect of Payoff Tables on Experimental Oligopoly Behavior

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Abstract:
We explore the effects of the provision of an information-processing instrument - payoff tables - on behavior in experimental oligopolies. In one experimental setting, subjects have access to payoff tables whereas in the other setting they have not. It turns out that this minor variation in presentation has non-negligible effects on participants' behavior, particularly in the initial phase of the experiment. In the presence of payoff tables, subjects tend to be more cooperative. As a consequence, collusive behavior is more likely and quickly to occur.

Keywords: Collusion; Cournot oligopoly; payoff tables; bounded rationality; framing; presentation effect
JEL Classification: D03; L13; C72; C92

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1 Introduction

Payoff tables[1] are widely used as an informational aid in experimental research in economics since its beginnings, especially in market experiments. Some of the pioneering experimental studies on oligopolies use payoff tables (e.g., Fouraker and Siegel 1963; Sauermann and Selten 1967; Dolbear et al. 1968) as well as recent ones (e.g., the majority of the reviewed experimental oligopoly studies in Huck et al. 2004 or Abbink and Brandts 2008). The influence of this device

[1] A payoff table is a matrix that depicts the payoff of player i for all possible combinations of i's and the opponent's actions. For example, in a Cournot market, the payoff table displays player i payoff is for all combinations of i's production choice and the competitors' total production.

on subjects' behavior, however, has not yet been explored systematically. With this study, we try to fill this gap.

If humans were perfectly rational as assumed in standard economic theory, one would not expect to observe any significant differences between the outcomes of experiments conducted with different information processing instruments. A cognitively perfect player is able to identify strategies and their payoff consequences, whether the information on the payoff structure is given as a mathematical formula or the equivalent information is listed in a payoff table. In reality, however, humans cognitive abilities are imperfect; their decision making process is subject to bounded rationality (Simon 1957). One of the observed effects of boundedly rational behavior is subjects' response to seemingly irrelevant differences in the presentation of experimental instructions. Numerous studies report such *presentation effects*. Pruitt (1967), for instance, reports more cooperation in the prisoner's dilemma game if the payoff structure of the game is presented to subjects in the decomposed form. In a duopoly experiment, Selten and Berg (1970) vary the amount of the starting capital by simultaneous reduction of within game profit. On contrary to the theoretical prediction, this variation *does* change subjects' behavior. More recently, Bosch-Domènech and Vriend (2003) investigate imitation behavior in Cournot markets with two and three competitors by varying the presentation of market information. They find that the frequency of imitation do not increase when the information retrieval gets more complex. In a gift-exchange experiment, Charness et al. (2004) find a significant reduction in both wages and worker effort when subjects are provided with payoff tables compared to the baseline treatment without payoff tables. Goerg and Walkowitz (2008) report that presentation effects may influence behavior in cross-cultural experiments in different ways. A positive framing may result in more cooperative behavior in one society while in the other it may have no influence.

It is important to distinguish between *presentation* effects and other *framing* effects. Presentation effects describe the change in subjects responses' to a decision task which is altered slightly though the underlying decision task remains the same. In contrast to pure presentation effects, *valence framing* effects occur due to the presentation of the decision situation in a positive or negative light (Levin et al. 1998). One of the most prominent examples of the valence framing effect was reported by Tversky and Kahneman (1981) on the choice reversal ("Asian disease problem"). In the economic literature, framing effects are mostly shown in public good settings (see e.g., Andreoni 1995; Cookson 2000; Brandts and Schwieren 2009). Abbink and Hennig-Schmidt (2006) provide a detailed discussion of different framing effects.

In this study, we focus on the pure presentation effect and conduct a series of Cournot market experiments with two presentational settings that differ slightly. In one setting named *TAB*, subjects are provided with payoff tables whereas they are not in the other setting (*noTAB*). Our main research interest concerns whether subjects in the two settings behave differently. In the context of an oligopoly, we may re-formulate our research question: Do competitors with an information processing aid tend to be more collusive than competitors without such an aid?

The payoff table we use in our study (see Appendix) reduces the complexity of the payoff structure by presenting all possible payoffs in a crystal clear way. This clarity may help subjects to realize better what alternatives they have and what the consequences of these alternatives are. In particular, subjects may identify collusive quantities more easily. Hence, we conjecture that payoff tables should lead to more collusive behavior and to higher profits.

Our study includes a complementary research question: What is the effect of the market size in our context? To investigate possible number effects we conduct experiments with two, three and four competitors. Previous studies with quantity setting oligopolies show that competition tend to increase when the number of competitors grow. Siegel and Fouraker (1963) observe more competition in the triopoly settings compared to the duopoly markets.[2] Huck et al. (2004) provide a comprehensive discussion of number effects in quantity setting oligopolies.

Our results show for all market sizes, average total quantities are lower when subjects are provided with payoff tables, i.e., in *TAB*, the markets are more collusive. In the initial phase of the experiment, the differences between both settings are most pronounced. Subjects provided with payoff tables choose more often collusive quantities, which leads to higher prices and profits *TAB*. Over time the differences between both settings get smaller. In both settings, competition increases when the market size grows. We observe, however, some tendency to collude even in markets with four competitors.

The next section presents the model. Section 3 describes the experimental design and procedure. Section 4 is dedicated to the results. Section 5 concludes.

2 The model

Since we focus on the impact of payoff tables we use a very simple Cournot model. In a Cournot oligopoly, N symmetric firms compete in a market where a homogenous good is sold. By x_i we denote the single quantity produced by the firm i (production is limited to 60 units per period). The total market production, i.e., the sum of x_i is represented by X. To simplify the problem without changing its nature we set the cost of production to zero. Furthermore, we assume a linear market demand where the computer "buys" the total production. The resulting price is denoted with p and the inverse demand function then is $p = \max\{60 - X, 0\}$. The firms decide simultaneously on x_i. The profit of firm i is given by $\pi_i = (60 - X)x_i$ for $X \leq 60$ and $\pi_i = 0$ for $X > 60$.

For each market size, one can easily calculate the Cournot-equilibrium, which is the only pure Nash-equilibrium of the stage game and yields positive profits for each player. We refer to this equilibrium as the Cournot-Nash-equilibrium (henceforth CNE).[3] The CNE is the first theoretical benchmark to which we

[2] Dolbear et al. (1968) find similar results in a price-setting experiment.

[3] The stage game also has other pure equilibria, e.g., $x_i = 60$ for $i = 1...n$.

Table 1: Total quantity and prices at benchmark outcomes

	Collusion		CNE		Competition	
Market size	X	p	X	p	X	p
$N = 2$	30	30	30	20	60	0
$N = 3$	30	30	45	15	60	0
$N = 4$	30	30	48	12	60	0

will compare the experimental results. The second benchmark to which we refer is collusion where all competitors act as if they were a single monopolist to maximize their joint profits. The third benchmark is the competitive outcome where firms maximize their profits given the market clearing price. Many experimental studies refer to these three benchmarks of quantity-setting oligopoly (see e.g., Offerman et al. 2002). Table 1 depicts the total quantities and prices in markets with two, three, and four competitors for the respective benchmarks.

3 Experimental design

Our experimental design contains two informational settings (*noTAB*, *TAB*) and three market sizes (two, three and four competitors), i.e., we have six experimental treatments. We conducted 10 independent observations per treatment; in total 180 students participated at nine experimental sessions. After the participants had entered the laboratory, the instructor read aloud the instructions[4] to be sure that every participant heard the information at least once. The subjects' assignment to different markets was random but fixed for the duration of the experiment. Communication was not allowed. A market period consisted of a decision and a feedback phase. After the subjects made their quantity decisions, all competitors received feedback about all single quantities and profits in their market. The participants played 100 experimental periods that lasted two and half hours on average including the introduction. The average payoff was about 18 Euros. The experiments were programmed with the experimental programming toolbox RatImage (Abbink and Sadrieh 1995).

4 Results

4.1 The Initial Effect of Payoff Tables

Result 1 *In the initial phase of the experiment, subjects with payoff tables choose more often collusive quantities than subjects without payoff tables.*

Already in the first period, subjects with payoff tables choose more often quantities that are closer to the collusive benchmark than to other benchmarks.

[4]For an English translation of the instructions, see the Appendix. The original instructions in German are available upon request from the authors.

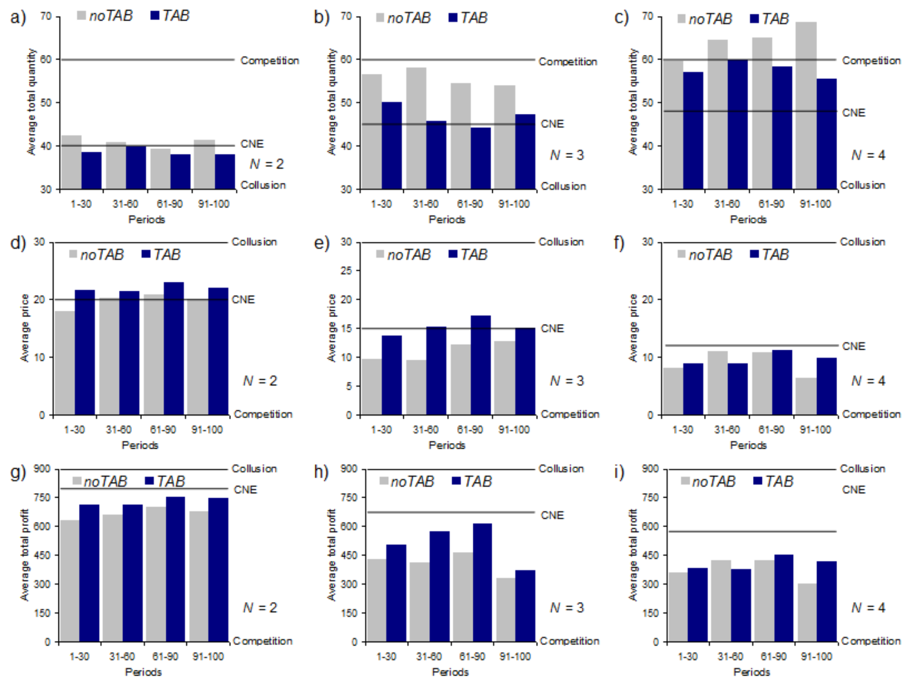

Figure 1: Average numbers in different phases

In *TAB*, on average, the absolute distance between a subject's quantity and the collusive benchmark is significantly smaller than in *noTAB* (Mann-Whitney U-Test, $p = 0.082$). Obviously, many subjects in *TAB* were able to immediately identify the joint profit maximizing (symmetric) quantity. In *TAB*, the initial collusive tendency continues in the consecutive periods. Averaged over the first five periods and aggregated over all market sizes, subjects in *TAB* choose significantly more often (U-Test, $p = 0.004$) collusive quantities (49% of all decisions) than subjects in *noTAB* (29% of all decisions).

Does the initial effect of payoff tables on subjects' quantity choices last in the course of the experiment or is it just a straw fire? In the following section, we tackle this question by looking at the aggregate numbers averaged over the whole experimental horizon.

4.2 Overall Total Quantities and Prices

Figure 1 displays average total quantities (panels a-c), market prices (panels d-f), and average total profits (panels g-h), for different market sizes. To study the differences over time, we divide the experimental time horizon in three phases each averaging the results of 30 periods. We consider an ending phase of 10 periods separately to exclude possible end game effects.

Result 2 *For all market sizes and in all phases, average total quantities are lower in TAB than in noTAB. With one exception, average prices are higher in TAB than in noTAB.*

On the aggregate level, there is a clear difference in behavior between subjects using payoff tables and those who do not have access to it. As can be seen in Figure 1, in all phases and for all market sizes, the average total quantity is lower in *TAB* than in *noTAB*. In addition, average prices are also higher in *TAB* than in *noTAB* in almost all phases and market sizes. The only exception where this is not the case is phase 2 (periods 31-60) of the quadropolies. As a consequence, average total (market) profits are also higher in *TAB* than in *noTAB*, in all phases and market sizes with the exception of phase 2 of quadropolies. Hence, the immediate strong effect of payoff tables observed in the beginning phase was indeed not a straw fire.

4.3 The Effect of the Market Size

What is the impact of the market size on average quantities and prices? The Cournot model predicts the increase of total output and the reduction of prices when the number of competitors grows.

Result 3 *In both settings, quantities (prices) decrease (increase) significantly when market size grows.*

Averaged over 100 periods, Jonckheere-Terpstra-Tests result in highly significant p-values showing that the larger the market size is the higher is the average total production (*noTAB*: $p = 0.007$; *TAB*: $p = 0.000$). They also show that in both settings the prices decrease significantly (*noTAB*: $p = 0.007$; *TAB*: $p = 0.001$) when the market size grows from two to three to four. Hence, our results confirm the predictions of the Cournot model and are in line with the experimental findings of Fouraker and Siegel (1963) and Huck et al. (2004).

In the next section, we investigate whether and how quantities and prices evolved during the course of the experiment.

4.4 Evolution of Total Quantities and Prices

In order to study the evolution of total quantities and prices we compare quantity averages obtained over periods 1-30 (phase1) to the averages of periods 61-90 (phase 3).

Result 4 *In TAB average quantities (prices) of triopolies and quadropolies decrease (increase) significantly from phase 1 to phase 3 while there is not such a decrease in noTAB. Average total quantities (prices) in TAB-duopolies start on a low (high) level and remain low (high) while noTAB-duopolies show a decreasing (increasing) trend.*

In *noTAB*-duopolies, average quantities are significantly lower in phase 3 (39.5) than in phase 1 (42.5) (Wilcoxon matched pairs test, $p = 0.030$). Consequently, prices in *noTAB*-duopolies are significantly higher ($p = 0.023$) in phase 3 (21.0) than in phase 1 (18.2). In *TAB*-duopolies, the decrease in quantities (from 38.7 to 38.2) is not significant since subjects with payoff tables - in contrast to subjects without payoff tables - choose low production levels already in the initial phase of the experiment. Analogously, in *TAB*, the increase in prices from phase 1 to phase 3 is not significant (from 21.8 to 23.0).

In *TAB*-triopolies, the average total quantity is significantly lower ($p = 0.053$) in phase 3 (44.3) than in phase 1 (50.2). The prices increase significantly from 13.8 to 17.4 ($p = 0.053$). In *noTAB*, there is no significant change neither in quantities (from 56.6 to 54.5) nor in prices (from 9.8 to 12.3).

We observe a similar pattern also in markets with four competitors. In *TAB*, the quantity in phase 3 is significantly lower (p = 0.065) than in phase 1. The prices increase from 8.9 to 11.4 ($p = 0.097$). There is, however, no significant decrease of quantities in *noTAB*. In 6 of 10 markets, quantities decrease while, on average, quantities increase from 59.6 to 65.1. Prices do not increase significantly (from 8.2 to 10.9).

4.5 The Long-Run Performance of Markets

As the above numbers show, in markets with three and four competitors, we observe a trend to more collusive quantities when subjects are provided with payoff tables while we do not observe such a trend in the *noTAB* setting. In the next section, we discuss markets' "long-run" performances by classifying them according to the markets' average quantities in periods 60-90. Previous studies use similar classifications, see e.g., Fouraker and Siegel (1963) or Huck et al. (2004).

We define a market as collusive (abbrev. COL) in the long-run if this market's average total quantity is closer to the collusive benchmark than to other two benchmarks introduced in Section 2. This means, a duopoly market is classified as collusive if this market's average total quantity is below 35 while the same market is classified as a "CNE-market" (CNE) if this market's average total quantity lies between 35 and 50. Applying the same logic we label duopoly markets with average quantities above 50 as competitive (COM). We define markets with an average total quantity exceeding 60 by more than 10% as punishment markets (PUN) since the experimental data reveal that such high average quantities often occured due to punishment actions taken by one or more competitors. We will discuss punishment acts in more detail below in Section 4.6.

Result 5 *In the long-run, there are more collusive markets in the TAB setting.*

Table 2 depicts the results of the classification. We count five collusive duopolies in each setting. Four duopolies in *TAB* achieve even a perfectly collusive outcome, i.e., the average total quantity in these markets amounts

Table 2: Classification of markets according to the long-run performance (Periods 61-90)

	noTAB				*TAB*			
Market size	COL	CNE	COM	PUN	COL	CNE	COM	PUN
$N = 2$	5	2	3	0	5	3	2	0
$N = 3$	2	3	2	3	4	3	3	0
$N = 4$	1	5	1	3	2	2	5	1
Total	8	10	6	6	11	8	10	1

exactly to the collusive benchmark of 30. In *noTAB*, only two duopolies achieve a perfect collusion. There are two collusive triopolies in *noTAB*, while in *TAB* we count four collusive triopolies. In *noTAB*, only one triopoly achieves a perfect collusion whereas in *TAB* two markets are perfectly collusive. We count one collusive quadropoly in *noTAB* and two collusive quadropolies in *TAB*. Hence, aggregated over all market sizes, there are more collusive markets in *TAB* (11 markets, 37% of all markets) than in *noTAB* (8 markets, 27%). Remarkably, we observe collusive behavior even in quadropolies.

Aggregated over all market sizes, in *noTAB*, there are ten markets with average total quantities around the CNE: two duopolies, three triopolies and five quadropolies. In *TAB*, there are eight CNE markets, three duopolies and triopolies each and two quadropolies. In *noTAB*, we classify six markets as competitive while there are 10 COM markets in *TAB*. Interestingly, there are six PUN markets in *noTAB* while there is only one single PUN market in *TAB*. Apparently, there is less need for punishment activities in *TAB*. For *TAB*, a χ^2-Test rejects the hypothesis that the observed market classification is normally distributed ($\chi^2 = 1.467$, $p = 0.043$) whereas the same hypothesis cannot be rejected for *noTAB* ($\chi^2 = 8.133$, $p = 0.722$).

4.6 The Collusiveness of Markets

The above classification reveals that many markets succeed to collude. Interestingly, oligopolies in *TAB* establish the monopoly quantity in significantly earlier periods than markets in *noTAB*.

Result 6 *In TAB, collusion is established significantly earlier than in noTAB. This is true in terms of collusive quantities as well as collusive prices.*

Figure 2 shows the evolution of the percentage of collusive markets in each setting, and aggregated over all market sizes. In the beginning phase (periods 1-30), in *TAB*, there are significantly more collusive markets than in *noTAB* ($p = 0.033$). The markets in *noTAB* catch up during the experiment with the markets in *TAB*. Nevertheless, averaged over 100 periods, there are more collusive markets in *TAB* than in *noTAB* ($p = 0.099$).

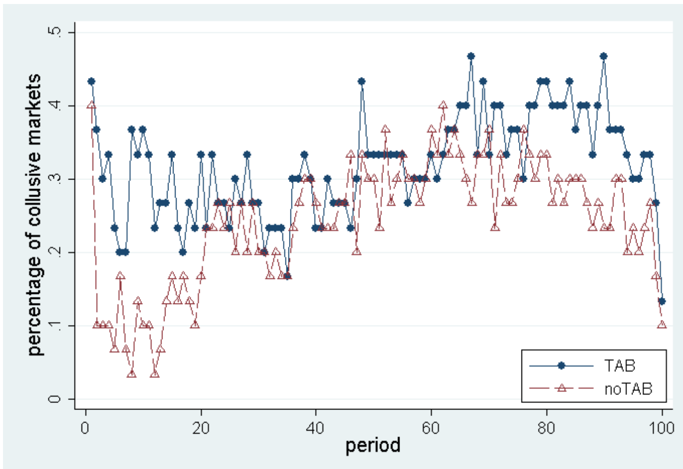

Figure 2: Relative frequency of collusive markets

Alternatively, we can use the price level as a measure to evaluate markets' collusiveness. We refer to prices above the CNE prices as collusive prices (cf. Huck et al. 2004). Aggregated over all markets, in the beginning phase (periods 1-30), there are significantly more collusive prices in *TAB* (35.4%) than in *noTAB* (20.4%, U-Test, $p = 0.030$). In both settings, in the last phase (periods 61-90) the percentages of collusive prices increase: in *noTAB* to 34.2% and in *TAB* to 44.1%. This difference, however, is not significant.

4.7 Individual Behavior

How do payoff tables influence the individual behavior? Since in our experimental design subjects receive detailed feedback about each of the competitors' quantities and profits, they were able to apply a variety of (behavioral) strategies. We focus on three strategies to which it is often referred to in previous studies on quantity setting markets: Best-reply, collusive response, and imitation. In our game, each competitor is able to unilaterally force the market price to zero by choosing $x_i = 60$. This choice can be interpreted as a punishment act since in this case the player who chooses 60 as well as all other competitors obtain zero profits for sure. For this reason, we consider punishment as a fourth behavioral strategy. In the following, we first explain these four strategies more in detail. Then we look whether and how often subjects did choose these strategies in the experiment.

Best-Reply: A player i playing a (myopic) best-reply strategy assumes that the sum of competitors' quantities will be the same in period t as in period $t-1$ and sets her actual quantity in period t according to the best-reply function $x_i^t = 30 - (X_{-i}^{t-1}/2)$ with X_{-i}^{t-1} being the sum of other competitors' last period quantities.

Collusive Response: A player i who applies the collusive response strategy wants to maximize the joint profits in the market, i.e., including her own quantity and those of her competitors. Thus she chooses x_i according to the formula: $x_i^t = 30 - X_{-i}^{t-1}$, i.e., the total quantity including player i's quantity equals the monopoly quantity.

Imitate the successful: An imitator i sets the own quantity to $x_i^t = 30 - x_j^{t-1}$, where i being the imitator and j the most successful competitor in the previous period.

Punishment: A punisher i chooses $x_i = 60$ to set the market price to zero.

Which of the strategies described above subjects follow? Are subjects in *TAB* more inclined to apply best-reply strategies than subjects in *noTAB* since the payoff table presents them the best-replies in a clear way? Do subjects with payoff tables choose more often collusive responses which were easily identifiable? On the other hand, because of the clarity, one could expect less imitation behavior with payoff tables. Punishment could be more severe without payoff tables because of the higher level of quantities.

Result 7 *The most frequent strategy subjects apply is collusive response, in both settings. Followed by imitation and best-reply in similar percentages. Subjects in noTAB punish more often than subjects in TAB.*

Table 3 depicts the relative frequencies we observed in our experiments. The numbers in parentheses depict the percentage of periods, in which a strategy was *applicable* which means that a player indeed was able to choose a particular strategy. Not all the strategies were applicable in each period. For example, a collusive response strategy is only applicable if the sum of the quantities in a market is less than or equal to 30. If the sum of the competitors' quantity is greater than 30, there is no reasonable collusive response.

Best-reply was applicable in 87.6% of the cases in *noTAB* and in 92.4% cases in *TAB*. In both settings, however, only less than 10% of the decisions are actually best-replies. This is surprising since the subjects had all necessary information to calculate the best-replies. In *TAB*, subjects could even read the best reply directly from the payoff table. Despite this, subjects in *TAB* (8.2%) do not choose significantly more often best-replies than subjects in *noTAB* (7.1%).

In *noTAB*, in 47.1% of all cases collusive response was applicable (in *TAB*: 50.8%). While in *noTAB* 28.6% of the applicable cases were actually collusive responses in *TAB* 37.4% of the decisions were collusive responses. Hence, collusive response is the most frequent observed decision rule in both settings, in relative as well as in absolute terms. Subjects in *TAB* choose more often collusive responses than subjects in *noTAB*. The difference between both settings is most greatest for the triopolies. In both settings, the amount of the collusive responses decline with the market size.

In *noTAB*, imitation was applicable in 36.9% of all possible cases (37.8% in *TAB*), however, it occurs in 10.1% of the these cases (10.9% in *TAB*). In duopolies imitation is more frequent (20.0% in *noTAB*, 16.3% in *TAB*) whereas it is rare in quadropolies (8.3% in *noTAB*, 7.8% in *TAB*). The discrepancy

Table 3: Observed decisions in percent of the applicable cases (in parentheses)

	noTAB				*TAB*			
Market size	BR	IM	CR	PUN	BR	IM	CR	PUN
$N = 2$	3.4	20.0	37.8	1.0	8.0	16.3	39.3	1.6
	(99.0)	(24.2)	(93.4)	(99.0)	(98.4)	(24.9)	(93.3)	(99.0)
$N = 3$	9.8	8.6	21.6	5.3	6.7	13.2	40.2	2.3
	(89.3)	(41.5)	(37.5)	(99.0)	(95.4)	(36.1)	(55.7)	(99.0)
$N = 4$	7.0	8.3	21.1	7.1	9.6	7.8	29.3	4.7
	(80.5)	(39.7)	(30.9)	(99.0)	(87.2)	(45.6)	(27.7)	(99.0)
Total	7.1	10.1	28.6	5.2	8.2	10.9	37.4	3.2
	(87.6)	(36.9)	(47.1)	(99.0)	(92.4)	(37.8)	(50.8)	(99.0)

between the imitation numbers in duopolies and in quadropolies could be due to the ambiguity of the intention of imitational decisions. Imitation must not necessarily mean to copy the most successful competitor. Sometimes imitation occurs in order to send a "message" to another competitor. For example, some subjects choose the symmetric collusive quantity and that of the competitor with the highest quantity alternately to signal that the competitor with the highest quantity also should choose the collusive quantity. It is clear, that this type of "signaling" works better if the addressee of the signal can identify that he or she is the addressee - as in the case of a duopoly.

Punishment was applicable with the exception of the first period, i.e., in 99.0% of possible cases. In *noTAB*, 5.2% of subjects punish while in *TAB* only 3.2% punish. In both settings, the use of punishment increases with the market size (Jonckheere-Terpstra-Test, $p = 0.026$ for *noTAB*; $p = 0.016$ for *TAB*). This reflects the increasing difficulties in collusive behavior when the market size grows.

5 Conclusion

In this study, we systemically investigate the effect of payoff tables on subjects' behavior in Cournot markets with two, three, and four competitors. We designed our study to strictly focus on the presentation effect of payoff tables. For this, the only variation between our two informational settings is the provision of a payoff table - all other things remaining equal. Hence, any differences between the both settings of our study can be unambiguously traced back to the presence (or the absence) of payoff tables.

Overall results show that subjects provided with payoff tables choose more often collusive quantities and obtain higher profits. With regard to quantities, there exist significant differences in the initial phase of the experiment. Subjects with payoff tables manage to collude earlier than subjects without payoff tables. Towards the end of the experiment, however, the differences between both settings get smaller. Thus, the length of the experiment seems to be an important determinant: in experiments with a small number of periods, payoff tables are more likely to make significant differences.

Our results show that payoff tables indeed affect subjects' behavior. In contrast to Charness et al. (2004), however, we find that payoff tables seem to support cooperative behavior. They observe significant reductions of average wages and effort levels in a gift exchange game when subjects are provided with payoff tables. One major difference between the study of Charness et al. (2004) and ours is that we study a simultaneous decision situation whereas Charness et al. (2004) study a sequential setting. Thus, the effects of payoff tables seem to be ambiguous and depend on the game type. Both ours and the study of Charness et al. (2004) show, however, that payoff tables *have* an effect on behavior. Future research may investigate deeper how different game types and the effects of payoff tables are related.

Our complementary research question concerns the effect of the market size. The evidence from the numerous previous experimental studies on Cournot oligopolies is the predominance of competitive behavior (see e.g., Holt 1995). Collusion is rare in markets with more than two competitors (Huck et al. 2004). We find that total quantities increase while prices decrease as the market size grows. Thus, our results are largely in line with previous studies though we find some tendencies for collusion also with four competitors. For all market sizes, the number of collusive markets are higher with payoff tables.

In the theoretical literature, we find many results on the presence and absence of information but very little on the significance of information processing instruments. This study clearly shows that information-processing aids have non-negligible effects. Everything that increases the understanding of the situation helps increasing the rationality in the decision making process. Payoff tables do this by unraveling the "hidden" information in the mathematical formulas. Our results show that this clarity indeed has impact on subjects behavior even in a simple setting. Hence, payoff tables might have even stronger effects in more complicated environments which possibly demand subjects' cognitive abilities even more. Thus, from a methodological point of view, the provision of payoff tables to the subjects may be useful and recommended, especially in complex experimental studies.

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6 Appendix

6.1 Translation of the Instructions to the Experiment

The Structure of the Experiment. The experiment consists of 100 periods. You will be randomly assigned to different groups. There are 2 to 4 participants in each group. The composition of each group does not change throughout the experiment. The members of a group are competitors on a market for a specific good. At the beginning of the experiment you will be informed, how many competitors you have.

The Structure of a Period. You determine your supply x, by choosing a number out of $\{0..60\}$. There are no costs, i.e., the good is produced and supplied without costs. Depending on your supply and the supply of your competitors, the total supply X on this market is determined as follows: $X = \sum_i x_i$, where x_i denotes the single supply of the supplier i on the market. The price p depends on the total supply X as follows:

$$p = \begin{cases} 60 - X & \text{if } X \leq 60 \\ 0 & \text{if } X > 60 \end{cases}$$

Your profit G is calculated as follows: $G = p \cdot x$. Your earnings depend on your final profit.

Feedback at the end of each Period. At the end of each round, each participant is informed about his profit G and the supplies and profits of his competitors. The profits of your competitors are determined in the same way as your own profit. Depending on the profit, every participant is paid a certain amount in the fictitious currency "Thaler". The screen shows the profit of the last period and the cumulated profit (sum of all profits obtained so far).

End of the Experiment and Total Payoffs. From the beginning, the exchange rate is displayed on the computer screen. At the end of the experiment your cumulated profit will be multiplied with the exchange rate. After the experiment you will be paid this amount.

Additional instructions for the setting "TAB". You will be provided with a payoff table. The lines on this table correspond to your possible supplies out of $\{0..60\}$. The columns correspond to the competitors' supplies (i.e., sum of the supplies of your competitors). In the respective fields of the table, you will find your corresponding profit.

6.2 The Payoff Table

Sum of the quantity of other competitors

Own quantity	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	3
2	116	114	112	110	108	106	104	102	100	98	96	94	92	90	88	86	84	82	80	78	76	74	72	70	68	66	6
3	171	168	165	162	159	156	153	150	147	144	141	138	135	132	129	126	123	120	117	114	111	108	105	102	99	96	9
4	224	220	216	212	208	204	200	196	192	188	184	180	176	172	168	164	160	156	152	148	144	140	136	132	128	124	12
5	275	270	265	260	255	250	245	240	235	230	225	220	215	210	205	200	195	190	185	180	175	170	165	160	155	150	14
6	324	318	312	306	300	294	288	282	276	270	264	258	252	246	240	234	228	222	216	210	204	198	192	186	180	174	16
7	371	364	357	350	343	336	329	322	315	308	301	294	287	280	273	266	259	252	245	238	231	224	217	210	203	196	18
8	416	408	400	392	384	376	368	360	352	344	336	328	320	312	304	296	288	280	272	264	256	248	240	232	224	216	20
9	459	450	441	432	423	414	405	396	387	378	369	360	351	342	333	324	315	306	297	288	279	270	261	252	243	234	22
10	500	490	480	470	460	450	440	430	420	410	400	390	380	370	360	350	340	330	320	310	300	290	280	270	260	250	24
11	539	528	517	506	495	484	473	462	451	440	429	418	407	396	385	374	363	352	341	330	319	308	297	286	275	264	25
12	576	564	552	540	528	516	504	492	480	468	456	444	432	420	408	396	384	372	360	348	336	324	312	300	288	276	26
13	611	598	585	572	559	546	533	520	507	494	481	468	455	442	429	416	403	390	377	364	351	338	325	312	299	286	27
14	644	630	616	602	588	574	560	546	532	518	504	490	476	462	448	434	420	406	392	378	364	350	336	322	308	294	28
15	675	660	645	630	615	600	585	570	555	540	525	510	495	480	465	450	435	420	405	390	375	360	345	330	315	300	28
16	704	688	672	656	640	624	608	592	576	560	544	528	512	496	480	464	448	432	416	400	384	368	352	336	320	304	28
17	731	714	697	680	663	646	629	612	595	578	561	544	527	510	493	476	459	442	425	408	391	374	357	340	323	306	28
18	756	738	720	702	684	666	648	630	612	594	576	558	540	522	504	486	468	450	432	414	396	378	360	342	324	306	28
19	779	760	741	722	703	684	665	646	627	608	589	570	551	532	513	494	475	456	437	418	399	380	361	342	323	304	28
20	800	780	760	740	720	700	680	660	640	620	600	580	560	540	520	500	480	460	440	420	400	380	360	340	320	300	28
21	819	798	777	756	735	714	693	672	651	630	609	588	567	546	525	504	483	462	441	420	399	378	357	336	315	294	27
22	836	814	792	770	748	726	704	682	660	638	616	594	572	550	528	506	484	462	440	418	396	374	352	330	308	286	26
23	851	828	805	782	759	736	713	690	667	644	621	598	575	552	529	506	483	460	437	414	391	368	345	322	299	276	25
24	864	840	816	792	768	744	720	696	672	648	624	600	576	552	528	504	480	456	432	408	384	360	336	312	288	264	24
25	875	850	825	800	775	750	725	700	675	650	625	600	575	550	525	500	475	450	425	400	375	350	325	300	275	250	22
26	884	858	832	806	780	754	728	702	676	650	624	598	572	546	520	494	468	442	416	390	364	338	312	286	260	234	20
27	891	864	837	810	783	756	729	702	675	648	621	594	567	540	513	486	459	432	405	378	351	324	297	270	243	216	18
28	896	868	840	812	784	756	728	700	672	644	616	588	560	532	504	476	448	420	392	364	336	308	280	252	224	196	16
29	899	870	841	812	783	754	725	696	667	638	609	580	551	522	493	464	435	406	377	348	319	290	261	232	203	174	14
30	900	870	840	810	780	750	720	690	660	630	600	570	540	510	480	450	420	390	360	330	300	270	240	210	180	150	12
31	899	868	837	806	775	744	713	682	651	620	589	558	527	496	465	434	403	372	341	310	279	248	217	186	155	124	9
32	896	864	832	800	768	736	704	672	640	608	576	544	512	480	448	416	384	352	320	288	256	224	192	160	128	96	6
33	891	858	825	792	759	726	693	660	627	594	561	528	495	462	429	396	363	330	297	264	231	198	165	132	99	66	3
34	884	850	816	782	748	714	680	646	612	578	544	510	476	442	408	374	340	306	272	238	204	170	136	102	68	34	
35	875	840	805	770	735	700	665	630	595	560	525	490	455	420	385	350	315	280	245	210	175	140	105	70	35	0	
36	864	828	792	756	720	684	648	612	576	540	504	468	432	396	360	324	288	252	216	180	144	108	72	36	0	0	
37	851	814	777	740	703	666	629	592	555	518	481	444	407	370	333	296	259	222	185	148	111	74	37	0	0	0	
38	836	798	760	722	684	646	608	570	532	494	456	418	380	342	304	266	228	190	152	114	76	38	0	0	0	0	
39	819	780	741	702	663	624	585	546	507	468	429	390	351	312	273	234	195	156	117	78	39	0	0	0	0	0	
40	800	760	720	680	640	600	560	520	480	440	400	360	320	280	240	200	160	120	80	40	0	0	0	0	0	0	
41	779	738	697	656	615	574	533	492	451	410	369	328	287	246	205	164	123	82	41	0	0	0	0	0	0	0	
42	756	714	672	630	588	546	504	462	420	378	336	294	252	210	168	126	84	42	0	0	0	0	0	0	0	0	
43	731	688	645	602	559	516	473	430	387	344	301	258	215	172	129	86	43	0	0	0	0	0	0	0	0	0	
44	704	660	616	572	528	484	440	396	352	308	264	220	176	132	88	44	0	0	0	0	0	0	0	0	0	0	
45	675	630	585	540	495	450	405	360	315	270	225	180	135	90	45	0	0	0	0	0	0	0	0	0	0	0	
46	644	598	552	506	460	414	368	322	276	230	184	138	92	46	0	0	0	0	0	0	0	0	0	0	0	0	
47	611	564	517	470	423	376	329	282	235	188	141	94	47	0	0	0	0	0	0	0	0	0	0	0	0	0	
48	576	528	480	432	384	336	288	240	192	144	96	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
49	539	490	441	392	343	294	245	196	147	98	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
50	500	450	400	350	300	250	200	150	100	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
51	459	408	357	306	255	204	153	102	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
52	416	364	312	260	208	156	104	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
53	371	318	265	212	159	106	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
54	324	270	216	162	108	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
55	275	220	165	110	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
56	224	168	112	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
57	171	114	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
58	116	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
59	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Figure 3: The Payoff Table